

Resilience, ecology and adaptation in the experimental city

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In the face of global urbanisation and climate change, scientists are increasingly using cities to experiment with more resilient forms of urban infrastructure. Experimentation represents the practical dimension of adaptation; it is what happens in practice when policymakers, researchers, businesses and communities are charged with finding new paths. This paper traces one particular lineage of experimentation to resilience ecology, which rejects the possibility of external control over a system, casting planning and administrative functions, and even scientists themselves, as part of a Social-Ecological System. Using insights from political ecology, laboratory studies and urban studies, the paper explores how ecologists involved with the Long Term Ecological Research Programme in the USA are embedding adaptive experiments into urban governance. Discussion focuses on the role of place in adaptive science, considering the political implications of ecologising urban governance and rendering it experimental.

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Introduction: resilience and urban adaptation

The inevitability of climate change is turning attention increasingly to the question of adaptation (Hulme 2008; Pielke *et al.* 2007; Tol 2005), but, lacking conceptual clarity, debates concerning its desirability or practicality often generate more heat than light (Burton 2008). Advocates hold that scientific uncertainty surrounding climate impacts precludes anything other than a reactive approach, and that adaptation has the potential to radically transform society. Detractors draw their battle lines against these positions, seeing adaptation as simply a smokescreen for 'business as usual' in the face of a largely neutered political arena (Swyngedouw 2007), or as a fancy-dress parade of one-off projects that distract from the serious business of mitigation and regulatory reform (Meadowcroft 2009). This paper traces a mode of adaptation situated within the increasingly influential policy discourse of resilience ecology, exploring the implications of ecologising urban governance and rendering it 'experimental'.

The rationale for viewing environmental questions through an urban prism is well-rehearsed. Globally, the number of people living in cities recently passed 50 per cent, and the challenge of adapting to climate change in the twenty-first century will primarily take place in cities in the developing world. As both harbingers of future conditions and test beds in which to establish more sustainable ways of living (Haughton and Hunter 1994; Hodson and Marvin 2009a), cities are subject to ever more vigorous ecological conceptualisation. The material, institutional and demographic density of cities constitutes a fecund field in which to study emerging forms of climate governance (Grimm *et al.* 2008).

The attraction of resilience to policymakers is fairly obvious. Its ontological acceptance of flux and epistemological obsession with learning seems ideally suited to the challenges of surviving in a world in which 'substantial and novel' impacts on the biosphere will take humanity into largely uncharted territory (Raudsepp-Hearne *et al.* 2010).¹ Championed as the mechanism by which to achieve sustainability, resilience features

heavily on influential urban research agendas (ICLEI 2009, 1). The International Human Dimensions Programme on Global Environmental Change (IHDP) recently launched its Urbanization and Global Environmental Change core project, dedicated to promoting international, interdisciplinary research on the environmental challenges facing urban areas (IHDP 2005). ICLEI's (2010) Resilient Communities and Cities Initiative, which constitutes one of its four key themes, has stimulated publications and initiatives amongst policy-makers at all levels. Along with Partnerships for Global Resilience, which brings together the International Centre for Sustainable Cities and United Nations Environment Programme, it represents an influential platform for leading international agencies concerned with urban environments. The World Urban Forum also continues to focus on resilience as a key goal for cities (Walisser *et al.* 2005).

That said, there is a clear political ecology to resilience. Transformed from an ecological theory into a socio-ecological governance framework in some 20 years, it constitutes a pseudo-scientific policy discourse that (wittingly and unwittingly) exerts considerable power over how things should be done (Forsyth 2003). For example, in presenting us with a world in constant flux, where periodic crisis and change are inevitable, it accepts change somewhat passively. Rather than question the all-too-human causes of crises (whether of the climatic or economic variety), resilience emphasises the need for individuals, communities or cities to simply get on with adapting to them. This tendency to naturalise crises resonates with neoliberal discourses of capitalism (Evans *et al.* 2009; and even Klein 2007), which preclude political debate concerning the wider causes and desirability of change. However, non-equilibrium approaches to environmental governance have been heralded by some geographers as the potential basis for an 'environmental politics of progressive social movements' (Zimmerer 2000, 358), offering more productive grounds for engagement than the conservative myth of a singular, stable Nature (Swyngedouw 2008). While not wanting to spoil the broth with a surfeit of ingredients, as the main non-equilibrium concept to achieve prominence in the field of environmental governance, the way in which contradictory political imperatives of resilience are playing out practically and conceptually warrant further elucidation.

The following paper works upstream from these broad considerations to focus on the emergence of a highly specific yet influential research programme in urban ecology, which conceives of the city as an integrated Social-Ecological System (henceforth 'SES'). Based on non-equilibrium theory, complexity and non-linearity, the most recent ecological incarnation of the city is distinctive in emphasising resilience and adaptive learning as the path to urban sustainability in the face of climate change. While mitigation is undeniably a global scientific endeavour, adaptation requires localised, applied knowledge, and the SES approach is representative of emergent forms of adaptive governance that abandon the Modernist dream of total control,² acknowledging the inherently unpredictable and unplannable nature of cities. Urban SES research thus offers a window on the epistemology of adaptation, especially the role of place in remaking the relation between knowledge makers and knowledge users in adaptive governance (O'Riordan 2004).

Particular attention is paid to the Baltimore and Phoenix Projects in the US Long Term Ecological Research Network, which have been critical in establishing SES as what Lakatos (1977) would have termed a 'research programme' in urban ecology. Drawing on the urban laboratories literature, the work of these scientists is explored to elucidate how the city is being negotiated as both the site and object of a nascent mode of experimental governance. Extensive use is made of secondary sources, including research proposals, reports and published material. The evolution of sanitary science, chemistry and physiology all occupy relatively familiar positions within the canon of urban historical research, but, perhaps reflecting the historical bias of science studies (Livingstone 2002), ecology does not. If the intuitions of this paper are correct, then the discipline of ecology is set to play as important a role shaping the cities of the twenty-first century as the sanitarians did in the nineteenth. The paper concludes by considering the wider epistemological and political implications of this mode of experimental governance for geographies of urban adaptation and transition.

Placing adaptation in the experimental city

While innovation became institutionalised under the neoliberal logic of urban competitiveness

(Lovering 1999), climate change is reinvigorating a need to 'cultivate new techniques of governance' for urban sustainability (Hodson and Marvin 2007, 303). Within this context, experimentation is supposed to prompt radical social and technical transition by testing out different technologies under a range of conditions in highly visible ways (Hodson and Marvin 2007, 317; Kemp and Rotmans 2005). Examples abound. The Asian Cities Climate Change Resilience Network, funded by the Rockefeller Foundation, explicitly seeks to enhance the adaptive capacity of urban areas in developing countries by facilitating experiments in the form of 'interventions ... [that] will span health, infrastructure, water, disaster, urban planning/development issues' (2009, np) amongst others. While *et al.* (2009) identify experimentation as a key element of carbon control, the dominant paradigm of environmental governance. Taking Manchester, UK, they convey the common rationale for experimentation neatly in the stark choice between either innovating in order to change what they do, or simply doing less. Academics are also embracing the experimental ethos; speaking of their experiences developing sustainability science in live policy contexts, Turnpenny and O'Riordan claim that 'this is a wonderful time to experiment' (2007, 104).

Figure 1 depicts the relation between resilience, adaptation and experimentation under carbon governance. If climate change is the driver and resilience the goal, then adaptation is the process through which transition will occur. In this sense, climate experiments are where governance is *located*; they represent the practical dimension of adaptation – what happens in practice, 'on the ground', when policymakers, researchers, businesses and communities are charged with finding new paths.

In the context of growing research budgets and an emphasis on partnership working between universities, government and industry, academic knowledge is playing an increasingly central role in urban adaptation and governance more widely (Krueger and Buckingham 2009; Perry and May 2007). But while experimental approaches to urban sustainability are blossoming, work on exemplary

sustainability projects in general has paid surprisingly little attention to their epistemological dimensions (Bulkeley *et al.* forthcoming; Joss 2010). Taking a high-profile example, the Mecca of sustainability that is Masdar City in the United Arab Emirates is being built as a living laboratory around the Masdar Institute (Evans and Karvonen forthcoming). The experiments in this paper represent the extreme end-point of a particular style of adaptive governance that seeks to feed environmental monitoring back into a management process, but it is one towards which an increasing number of large-scale urban sustainability research projects are headed.

The sustainable city today is characterised by forms of scientific-administrative knowledge that are 'enmeshed in the particularities of places' (Bulkeley 2006, 1029), and which respond to a clearly defined set of urban problematics. Stephanie Pincetl compares the sanitary city of the nineteenth century with the sustainable city of the twenty-first, noting that, 'the problems [have simply] changed from cholera and polio, to particulates, volatile organic compounds, and other kinds of chemical pollution' (2010a, 47). Although the co-evolution of the urban sanitary movement and modern medical science is perhaps the most well documented (Melosi 2000), many branches of science developed in the context of specific urban problems, to the extent that the Modern city was 'co-produced' with a set of technical knowledges and planning practices (Dierig *et al.* 2003, 3).³ While urban historians have tended to view cities as the site of knowledge application, historians of science have demonstrated that they play an active role in producing scientific knowledge. Shapin and Schaeffers' (1989) classic account of Boyle's pump showed the key function played by the city in promulgating and embedding experimental scientific discovery through public spaces such as institutes. Cities are often the passive recipients of interventions that are simply 'dropped' into place with little consideration of local conditions (Hodson *et al.* 2008; Pincetl 2010b). Experiments in this sense are more about testing existing forms of knowledge and technology than with processes of learning and

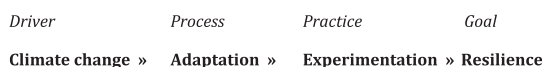


Figure 1 Resilience, adaptation and experimentation under climate change governance

urban adaptation. Squaring the place specificity of experiments with demands for abstract (placeless) knowledge is an inherently geographical tension that inhabits debates surrounding adaptation and transition more generally (Monstadt 2009; Powell 2007).

Recent work on the Chicago School of urban sociology is illuminating on this point. The Chicago School established a specifically scientific brand of sociology in the 1920s and 1930s, which borrowed 'legitimising rhetorics' (Gieryn 2006, 7) unashamedly from ecology to suggest that Chicago possessed an objective reality that was knowable and against which abstract claims could be tested. The process of scientific knowledge production involved moving from the specificity of Chicago as a place (the field) to the generic applicability of Chicago (and the knowledge made therein) as 'any city' (the lab). As a field site, the city exhibits a specific reality that is found, and that possesses an incontestable, singular truth by virtue of its lived materiality. In contrast, the city as lab becomes the cipher for any city, interchangeable and controllable through the manipulation of variables, possessing a truth borne of replicability. For Gieryn, the explanatory power of the Chicago school involved shuttling back and forth between these modes of knowledge legitimisation (see Figure 2).

Methods, styles of writing and modes of analysis mirrored this shuttle from the field to the lab, as the researchers shifted from presenting themselves as ethnographers with intimate knowledge of place and interpretive skill, to scientists merely deploying objective technology and methods to produce replicable, abstract results. This slippage also structures the rationale given for selecting Chicago in which to work, as the field-site must simultaneously be uniquely suited to the study of the questions at hand, while also representative of a general population of potential cases. So, although the Chicago School 'was tightly connected to its home city, epistemologically and politically' (Gieryn 2006, 9), their truth claims necessitated that the expediency for choosing to work in that particular city be covered up.

Of course, the dilemma of localism exercises science studies more generally. While science is always situated, and the object is always the 'grounds of local credibility' (Powell 2007, 312), science that is geographically specific is generally viewed as not being authentically true at all. But to view science solely as the overcoming of the local is mistaken. In Latourian mode, Secord notes,

it is not so much a question of seeing how knowledge transcends the local circumstances of its production but instead of seeing how every local situation has within it connection with and possibilities for interactions with other settings. (2004, 664)

Dierig *et al.* have highlighted how

urban expertise often consisted of a heterogeneous patchwork of overlapping blocks of knowledge rooted in different disciplines and often blurring the boundaries between academic and administrative knowledge cultures. (2003, 7)

Accordingly, the story of urban sanitation in Victorian Britain is told as one of how public health professionals engaged with the sanitary movement in order to gain positions within city administrations that would allow them to put their ideas into practice. Such accounts direct our attention towards the way in which the city has always been *experimental*, in the sense that new knowledges are tested in order to alter the way in which the city is administered. As the urban scientist works to cure urban problems, the city becomes a laboratory-clinic, in which cures are both developed *and* practised, prompting a constant renegotiation of the boundaries between science and non-science (Dierig *et al.* 2003, 10). As we shall see, the coalescence of science and administration under the rubric of urban ecology presents an excellent example of such renegotiation.

Urban ecology and the sustainable city

While the antipathy of Western environmentalism consigned urban ecology to neglect for many years, there is a long history of conceiving cities in loosely

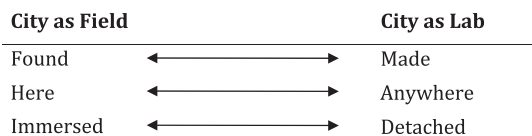


Figure 2 Shuttles between legitimisation strategies (after Gieryn 2006, 11)

organic terms as systems that display natural traits like growth and self-organisation. Understandings of the natural world have historically informed urban design, from the circulatory boulevards of Haussman's Paris to the soothing rhythms of Howard's Garden Cities. In his magisterial account, Davison concludes that

natural theology was arguably the midwife of urban sociology, for without its presence at the birth, witnessing to the orderliness of nature, and society, it may be doubted whether a systematic and holistic study of urban society would then have been attempted at all. (1983, 370)

And so for urban ecology. While the city has only recently been explicitly conceived as an ecological system, the organicist legacy at least partially accounts for the alacrity and enthusiasm with which ecosystemic approaches to urban areas have been adopted in recent years, despite the suite of challenges that attend conceiving cities in this way.

Urban ecology emerged as a sub-discipline in the 1970s, marked by UNESCO's establishment of their Man and Biosphere Programme in 1971, applying the 'earth systems' approach to conduct systematic studies of climate, soil, water and organisms (Duvigneaud 1974).⁴ The earth systems approach, which established the environment as something governable (Hulme 2008), complemented organicist convictions concerning the coherence of cities, providing a conducive climate for the establishment of systemic approaches to urban environmental science. That said, while ecosystem approaches to cities can be identified in the 1970s, they tended to focus on applying ecological principles to cities, rather than developing specifically urban ecological principles.

Large-scale funding manoeuvred ecosystemic approaches to cities up the environmental agenda in the post-Rio era (Weiland and Matthias 2009), with the result that redesigning the urban metabolism in view of sustainability goals became a relevant research question for urban ecology (Alberti 2008; Breuste *et al.* 1998; Brunner 2007; Pickett *et al.* 2004). Weiland and Matthias (2009) term this most recent era 'applied urban ecology as a contribution to sustainable urban development', clearly echoing the aspirations of the nineteenth-century sanitarians to be 'useful' and address extant urban problems. Systemic ecology has thus emerged in the current era of eco-towns and sustainable cities as an *explicit* knowledge base for urban planning,⁵ to

the extent that 'in policy and planning the term urban ecology is synonymous with "sustainable cities"' (Sukopp 2008, 79).

Ecologists themselves increasingly argue not only that urban ecosystems require attention (because humans dominate the earth's ecosystems), but that models should include humans in order to be generally applicable (Marcotullio *et al.* 2003; Vitousek *et al.* 1997). In light of this, Grimm *et al.* (2000) suggest that urban ecology requires a fundamental shift from ecology *in* cities to the ecology *of* cities. The components that such an ecology might be made up of are indicative: 'entire system', 'whole system metabolism', 'metapopulation approach', 'ecological footprint', 'watershed approach', GIS and remote sensing, 'city as ecosystem' are all approvingly listed (Grimm *et al.* 2000, 574). Building on previous work (Ehrlich 1997; McDonnell and Pickett 1993), Grimm *et al.*

present a call to action for ecologists to integrate their science with that of social scientists to achieve a more realistic and useful understanding of the natural world in general and its ecology in particular. (2000, 571)

But whilst urban ecology has ambitious plans to establish concepts that work across multiple scales, unite ecological and social understandings and address real-world urban problems, the scientific basis for such a synthesis does not yet exist. The key conceptual framework within which these hypotheses are currently being negotiated is that of SES, and the cities in which the experiments are occurring are Baltimore and Phoenix, USA. It is to the activities of the urban ecologists in these two cities that we now turn.

The city as a social-ecological system

The establishment of the city as an SES can be traced to the Long Term Ecological Research (LTER) sites in Baltimore and Phoenix in the United States and their collaborators. The LTER programme, funded by the National Science Foundation from 1980 up to the current day, represents the flagship environmental science research programme in the United States, comprising 24 ecologically diverse sites, an annual direct budget of almost \$20 million and approximately 1100 scientists and students. In 1997 the NSF added two metropolises (Phoenix and Baltimore) to their portfolio of sites,⁶ and both projects were granted second phase funding in 2004. Led by influential

urban ecologists Nancy Grimm at Arizona State University and Steward Pickett at Baltimore, both research teams adopted a large-scale ecosystems approach, sold themselves on the potential to use their cities as field laboratories, and emphasised the virtues of a comparative approach between cities. The Phoenix and Baltimore groups have fought to establish urban ecology as something new and worthy of study within the LTER programme, while maintaining its conceptual continuity with the discipline of ecology.

In the first phase until 2004, the projects sought to ratify the assumption that the city is a system as the edifice upon which the entire programme is built. While conceiving of the city as an ecosystem requires a 'radical expansion of ecology' (McDonnell and Pickett 1990, 1231), the systems approach maintains the link with the parent discipline of ecology. The leader of the Phoenix project quotes the grandfather of the ecosystem concept, Arthur Tansley, saying that, 'scientific analysis must penetrate beneath the forms of the "natural" entities, and ... be applied to conditions brought about by human activity' (1935, 304; in Grimm *et al.* 2000), while the Baltimore project states that

its goal is to develop a thoroughgoing understanding of metropolitan Baltimore as an ecological system, and to share this understanding with educators and decision makers. (Pickett 2004, 3)

More recently, Pickett has also appealed to Tansley to legitimise urban ecological research (Pickett and Grove 2009).

The challenge in urban ecosystems is to move from seeing human activity purely as an external factor causing disturbance, to being a driver and limiter of ecological processes in its own right. In the first phase of the projects, the question of exactly how to do this was highly problematic. As Grimm and Redman note,

standard ecological theories are insufficient to address the complexity of human culture, behaviour, and institutions; thus, our ecological investigations require the integration of social science research, require longer time horizons, and must be informed by flexible models and multi-scaled data. (2004a, 13)

The volition of human decisionmaking means that social factors cannot be modelled as just another organism in a traditional population framework (Padoch 1993), leading Redman *et al.* (2004) to acknowledge that there is no strong theoretical basis or research agenda for coupling natural and

human systems across the LTER program (NSF 2002).

Initially, social processes were dealt with fairly basically as a system paralleling the ecological system. Grimm *et al.* (2000) followed Pickett (1997) in mapping the physical drivers of ecosystems identified by the LTER more widely onto social drivers. So flows of energy become flows of information, the cycling of materials becomes the creation and maintenance of institutions, trophic structure becomes economic system, disturbance becomes design, and so on. While much could be said about the validity of these attempts to generate components of a social 'system', it is enough here to note that the social elements incorporated tend to reflect the limitations and weaknesses of the disciplines from which they were drawn. Criticisms of the abstract rational human actors so beloved of economists, the procedural obsession of institutional political theorists, and the neglect of social context displayed by psychologists all apply to the conceptualisations of social systems framed within this kind of urban ecology.

Like Chicago, the city plays a dual role as somewhere that is uniquely privileged as a site for this kind of research, and yet representative of the general case. As a de-industrialising city, Baltimore suffers widespread problems but is claimed to be uniquely suitable due to its long history of ecologically informed social research, the wealth of existing data and the established relations between researchers and local stakeholders. By comparison, the Phoenix proposal plays upon its status as a young city characterised by rapid growth rather than redevelopment, reeling off a wealth of facts and figures in the funding application concerning population growth and the associated impacts on water and biodiversity (Grimm and Redman 1997, 9). This justification is reinforced in the second proposal, suggesting that the sixth-largest city in the US is an ecological harbinger of the future, much like LA in Mike Davis' *City of quartz* (1990; Gieryn 2006).

Despite the differences between the two places, robustness of comparison is ensured by applying common scientific approaches and methods. For example, 'we maintain an ecological focus in the interest of comparative ecology and integration of our research findings with other sites of the LTER network' (Grimm and Redman 1997, 9). In a subsequent publication, Grimm *et al.* (2000, 578) state that 'although the two cities are quite different,

integration is furthered by a common approach to spatial analyses: a hierarchical patch dynamics approach'. Questions of scale and social-ecological integration are addressed technically. For example,

by considering patch dynamics simultaneously at multiple scales with an accompanying hierarchy of models, the complexity of urban systems is rendered more tractable and translation of information across scales is facilitated (2000, 578)

and, similarly, 'socioeconomic factors will be represented by multiple data layers in our modelling' (Grimm and Redman 1997, 10). Gieryn's shuttle between city as field and lab is intact at this stage of the research.

The need to standardise the city through modelling resonates with an anxiety many ecologists have about treating the city as 'just another' ecosystem (Pickett and Grove 2009). For example, McIntyre *et al.* (2000, 5) uncomfortably suggest that despite lacking a definition of 'urban', it is important to furnish 'an interdisciplinary, quantitative, and considered description of an urban ecosystem such that projects and findings are easier to compare, repeat, and build upon'. Place is manipulated quite cleverly in subsequent papers communicating joint findings from the two LTER sites to make a virtue out of the differences between the cities. Because Phoenix and Baltimore differ in almost every conceivable way, it is suggested that models operating successfully in relation to both have standing as generalisable urban ecological science. This argument has the added benefit of validating the multi-site approach of the LTER programme more generally. Rather than shuttling between ethnographic specificity and scientific generality as the Chicago School did, the Baltimore and Phoenix teams use a comparative method to put localism to the service of abstraction.

In 2004, both projects received follow-on funding from the NSF to develop their integrative approach to cities, and this marked a watershed in their conceptual approach. In the second phase both the Baltimore and Phoenix projects drew on the work of ecologists at the Resilience Alliance, in particular their work on SES (Berkes *et al.* 2001 2003; Gunderson and Holling 2001). Funded by Mistra (the Swedish Foundation for Strategic Environmental Research), the Resilience Alliance has seamlessly married its scientific work to an aggressive campaign to influence international policy. The Resilience Alliance is the key conduit for urban

resilience thinking (Colding *et al.* 2006; Folke *et al.* 1997), incorporating the SES approach into their recently established Urban Resilience research programme (Barnett and Bai 2007), which, in addition to the LTER urban programmes (Grimm and Redman 2004b, 199), have ensured that resilience features in major international urban research initiatives.⁷

The SES approach draws closely on the contemporary view of ecosystems as complex adaptive systems (Levin 1998), which, rather than existing in equilibrium with their surrounding conditions, can occupy multiple stable states. The central lesson of resilience thinking is that environmental managers should avoid optimising a system to one specific set of stable environmental conditions, as they will reduce the ability of the system to adapt when those conditions change (Gunderson *et al.* 1995). Calling this the 'pathology of resource management', Holling states, 'if this perspective is used as the exclusive guide to the management activities of man (*sic*), exactly the reverse behaviour and result can be produced than is expected' (1973, 15).

Redman *et al.* define an SES as a

coherent system of biophysical and social factors that regularly interact in a resilient, sustained manner; a system that is defined at several spatial, temporal, and organizational scales, which may be hierarchically linked; a set of critical resources (natural, socio-economic, and cultural) whose flow and use is regulated by a combination of ecological and social systems; and a perpetually dynamic, complex system with continuous adaptation. (2004, 163)

In addition to recognising the equal importance of social and ecological domains, the SES approach suggests that social and ecological systems are linked by multiple feedbacks, and display common properties, such as resilience and complexity. The SES approach has obvious appeal to ecologists working in cities, and both second round LTER bids adopted the SES framework. While the determinism of social-systems thinking remains problematic, the sophistication through which physical and social systems are linked using multi-scalar feedback loops is obviously suited to the urban context. The SES paradigm still conceptualises the *whole* city, but acknowledges its inherent unplannability. This seeming paradox is wrapped up in the organising metaphor of the system – not that of the nineteenth-century super-organism, but rather the non-linear system of post-equilibrium

thermodynamics in which the observer is part of the system under study. Modernist tropes of planning, managing and regulating the environment are thus replaced with governance-style metaphors of 'navigating', 'surfing' and even 'dancing' crises (Berkes *et al.* 2003; Gunderson 2003).

Adaptive experimentation

Focusing on adaptation rather than management renders scientific engagements with the city inevitably *experimental*, *applied* and *local*. The ecological grandfather of resilience, 'Buzz' Holling (2004) himself calls for the creation of conditions that promote multiple low-cost innovative experiments in governance. Working from this understanding, Grimm *et al.* state in a recent paper that,

cities offer real-world laboratories for ecologists to understand these fundamental patterns and processes and to work with city planners, engineers and architects to implement policies that maximise and sustain biodiversity and ecosystem function. (2008, 759)

The way SES casts the city as a terrain for scientific experiments differs distinctively from the activities of the nineteenth-century sanitarians, who generated knowledge within the city and then sought to influence its administration. In line with second-order cybernetics, once the observer is part of the system under study, ontological uncertainty in the system is mirrored by epistemological uncertainty of knowledge about it. On this understanding, Gieryn's distinction between field and lab begins to dissolve; without an external observer it is hard to satisfy the preconditions of the traditional laboratory as a controllable and separate space. In explicitly placing scientists within the system under study, the SES approach turns reality into an unavoidable and ongoing experiment.

The centrepiece of the Baltimore follow-on funding application was a nearly \$1 billion, 6-year 'experimental manipulation' of nitrogen exports in the watershed to improve sanitary sewer infrastructure (Pickett 2004, 8). In 2002, the city of Baltimore reached an agreement to bring the city into compliance with the Clean Water Act and end discharges of raw sewage into local waterways. Terming it a 'natural experiment', the Baltimore Ecosystem Study project team hardwired stream sampling equipment into this infrastructure project to provide a basis for adaptive management. Monitoring a diverse range of sites, they aim to enhance

the reduction of pollution through intervening in specific areas, and adapting regulation after infrastructure improvements.

The second phase of the Central Arizona-Phoenix programme also placed experimental work at its core, setting up a large-scale landscape experiment around student housing on the Arizona State University Polytechnic Campus (Grimm and Redman 2004a, 3). The recently established North Desert Village is the first ever experimental study of interactions between people and their ecological environment at the neighbourhood scale. As well as manipulating vegetation types and irrigation methods, the experiment is exploring how landscape interactions affect human perceptions and behaviours. Residential landscapes at identical housing units in the village were installed in four different styles designed to reflect different habitats found throughout the Phoenix metropolitan area. These ranged from a mesic landscape, which used a mixture of exotic high water-use vegetation and shade trees with turf grass maintained by flood irrigation to reproduce the classic (and largely unsustainable) suburban garden type, to the Sonoran Desert landscape, which reproduced native plants on granite substrate with no supplemental water whatsoever.

In a paper documenting the North Desert Village experiment, Cook *et al.* (2004, 467) ask why manipulative experiments are not used more in studies of human-environment interactions, despite the key role that experimentation usually plays in science. Capturing complex feedback mechanisms between social and ecological systems is complex and unpredictable, which, they argue, requires 'new and innovative research methods'. They suggest that adaptive experimentation is one such method that allows humans to adapt inside the experiment and alter its parameters, and they claim that experimenting on humans *in situ* produces 'more accurate scientific models' (2004, 467). The preferences of North Desert Village residents were used to design the area, and subsequent preferences while living in this constructed space informed ecological management decisions. In order to legitimise the North Desert Village as a scientific space, it is depoliticised and described as a laboratory; 'adaptive experimentation incorporates most of the formal aspects of classic experimental design, including independence of study units, use of replicates, and controls' (2004, 467). Tellingly, they champion adaptive experimentation over adaptive

management, on the grounds that the latter is more political.

While budget, interdisciplinarity and ethics all colour the practical appeal of adaptive experimentation (as they pithily note, 'plant or animal populations typically do not have a choice about participation'; 2004, 473), they identify a key trade-off between the detection of human causality (and thus enhanced experimental realism), and the wider applicability of the results. Because the practicalities of experiments usually limits them to relatively small and confined areas the problem of localism rears its ugly head, and they acknowledge that 'findings from experiments are to some extent confined to the setting in which they are carried out' (2004, 473). But the dream of general scientific validity is not abandoned. Their solution is to base wider applicability on the integration of adaptive experimentation with 'biological monitoring, social surveys, simulation modelling and comparative work at larger scales' (2004, 473). As one group of leading urban ecologists have tellingly commented, 'despite these significant efforts, we have only begun the process of developing a *comprehensive knowledge base* for building more sustainable cities and regions' (Musacchio and Wu 2004, 176; emphasis added). The integrated city is still a dream for these scientists;⁸ despite its un-plannability, it can be *known*. In this way the lessons from specific experiments can be generalised as placeless, and thus authentic, science.

This mode of experimentation turns the city into a laboratory; not by hardwiring science into the direct administration, design and planning of the urban landscape, but by assimilating these functions into the study itself. Within the urban SES approach, nothing is outside the lab. Experiments of this kind present a series of discomfiting questions: if the city is a laboratory, then are its inhabitants lab rats? More seriously, what sort of city (and, by implication, society) will result if urban design and administration is reduced to a set of environmental feedback loops? And at a more abstract level, what happens to science when it becomes verified through live experiments in which its own practitioners are implicated?

The politics of the experimental city

Epistemologically, it is possible to identify a shift from the dualistic tension between nomothetic (general) and ideographic (local) knowledge to a

position that, while not going so far as to outright reject the possibility of 'pure' knowledge, certainly adopts a more circumscribed view of objectivity. In their first NSF proposal, Grimm and Redman talk about using the city as a laboratory to study the relation of pattern and process, but state

while we would prefer to do hypothetico-deductive hypothesis testing using experimental manipulations in the field, this is possible in only a small subset of the research areas we have identified. (1997, 10)

On the following page they note that nomothetic modelling and long-term research is to be complemented by a series of ideographic 'experiments'. The concern for the localism of the experimental approach here echoes Gieryn's dualism between the city as field and the city as laboratory.

This concern shifts discernibly in the second phase of the projects. Within the SES framework the city cannot be 'knowable', only 'changeable'. Experimental cities are thus truth-making machines that draw no distinction between the generation and application of knowledge; as both the condition and site of change they destabilise the boundary between field and lab (Kohler 2002). This recalls an earlier mode of knowledge production, whereby naturalists and philosophers used to perform experiments in a range of places, such as parks and public houses (Klein 2008). While the emergence of modern science as pure epistemology effaced the material conditions of knowledge production, the ensuing distinction between pure and applied knowledge was really only briefly tenable in the early twentieth century. For the promiscuous experimental approach of the new urban ecology and adaptive experimentation, the messiness of place is constitutive of, rather than antithetical to, scientific practice (Dierig *et al.* 2003).

Adaptive epistemology thus translates into concomitant material changes. Talking about decentralised green infrastructure, Pincetl notes the tension between believing

that good science and information will yield better results – a modern, progressive view – and at the same time ... question(ing) the dominant structure of knowledge and organisational form of cities. (2010, 52)

In the experimental city, sustainable test settlements like BedZed are literally embedded in the urban fabric as truth spots in their own right. As Gieryn (2008, 797) argues in his study of Stanford's Clark Centre for biotechnology, the lab itself is an 'experiment' linking the production of

scientific knowledge with economic interests through a design that echoes the disembedded architecture of high capitalism associated more commonly with airports and art galleries. Similarly, in the competition to display the most shining example of urban sustainability design, the scientific urban experiment becomes simultaneously cultural and economic. The implication of the North Desert Village is that if it is popular with residents, then the knowledge deployed is, in some extra way, valid. As objectivity recedes from view, truth becomes synonymous with success, becoming embedded in the city in no less material a way than those twentieth-century monuments to wealth, skyscrapers. Within the experimental landscapes of sustainability, place is critical as the visible arbiter of truth.

Resilience privileges places that have the capacity to become truth spots. Just as the rapid development of the science of pathology in nineteenth-century Paris reflected the high number of hospitals and cadavers available to work in and on (Dierig *et al.* 2003), so a similar competitive advantage will accrue to cities with the knowledge base and institutional capacity to experiment with urban sustainability (While *et al.* [2009] make a similar point regarding carbon control). Successful experiments will become increasingly important to urban and regional economic trajectories (Gibbs and Krueger 2007), but the experimental capacities of cities are not evenly distributed (Hodson and Marvin 2009b). Feedback loops dissolve the boundaries between knowledge makers (universities) and knowledge users (administrators), but the fusion of science and city that characterised the western world is less well established elsewhere, with important implications for thinking about how an urban ecological approach might be embraced in different contexts.

Politically, the experimental city resonates with notions of complexity and non-linearity espoused in the social sciences, and it is not hard to find instances where the city is spoken of in remarkably similar terms to those of an urban SES. For example, Amin and Thrift call for a new type of urbanism that understands urban development 'as a set of potentials which contain unpredictable elements, as the result of the co-evolution of problems and solutions', or what they call the 'ordering of uncertainty' (2002, 4). In a particularly telling phrase they speak of the city as an 'ecology of circumstance' (2002, 77), which requires 'performative

improvisations which are unforeseen and unforeseeable' (2002, 4). In a not entirely dissimilar vein, cultural anthropologist James Holston suggests that the multiplicity and simultaneity of urban processes makes any attempt at comprehension 'experimental' (1999, 155), but notes that the experimental mode articulates a shared acceptance of contingency and uncertainty between democracy and neoliberal planning (Caldeira and Holston 2005). In abandoning a political project of regulatory reform, the formally sanctioned optimism of resilience and reactive localism of experimentation runs the risk of fiddling while Rome burns (Vale and Campanella 2005) – tensions that inhabit the policy discourses of resilience and adaptation more generally (Evans and Karvonen forthcoming).

SES models advocate public participation (Gunderson and Holling 2002; Walker *et al.* 2002) to facilitate place-specific agenda setting, but the experimental space is conceptually constrained within bounds of what can or cannot happen inside an SES. The specific characteristics of the SES are modifiable, but the fact that the city is an SES is non-negotiable. In other words, the scientific assumptions of resilience ecology run the risk of political foreclosure because they frame the governance choices that are available, often in feedback mechanisms that are seemingly neutral. There is a danger that despite (or perhaps because) of its embrace of complexity, resilience smuggles Davison's ghost of natural theology into the practices of experimental governance. Ironically, it may be exactly the emphasis on flux (and the rejection of stable Nature), which appeals to geographers as the basis for a more progressive environmental politics, that produces this political foreclosure.

This appropriation of governance in turn raises the question of what *should* be political in the urban context. While undoubtedly ethical, the work of the sanitarians in the nineteenth century was in no way democratic. In their defence, it can be said that they dealt with basic needs, rather than political choices and social futures. But if this distinction was tenable then, it is less so than ever today, as urban services such as water, medicine and clean air become politicised through processes of privatisation (Graham and Marvin 2001; Swyngedouw 2004), and our 'basic needs' impinge upon those of future generations (Dobson 1998). Seeing the city as an SES threatens to de-politicise urban transition, not so much by colonising arenas of governance with expert knowledge (à la Modernism),

but by constraining governance within a technocratic mode that remains inured to the tropes of scientific legitimacy.

Conclusions

This paper has offered an account of the conceptual basis of adaptation in resilience ecology, highlighting the importance of urban experiments and place for political debates concerning adaptation, transition and sustainability. While cities have always been in some sense 'experimental', the SES framework couching the new urban ecology is altering the relationship between science and city. While it would be folly to suggest the forms of adaptive governance studies in this paper are *currently* dominant, the SES approach offers a window on the possible implications that might flow from ecologising the city in this way, and re-rendering urban adaptation experimental.

With the death of the detached observer and the incorporation of research, planning and administration into the system under study, so the possibility of abstract 'placeless' knowledge also dies. Place mediates the adaptive apparatus of climate governance, but is caught in a kind of limbo. Not only do the models of scientific veracity that would traditionally demand the effacement of place no longer hold under the conditions of complexity that are embraced by SES-type models, but, as objectivity is lost, place becomes inescapable as a highly visible testament to truth in urban landscapes. Thus we find the writings of resilience ecology replacing the language of generally applicable knowledge with a commitment to discovering generally valid meta-principles and frameworks to guide how adaptive experimentation should progress to produce resilience. In mirroring the ontology of climate change, which is one of *change*, resilience and adaptive epistemologies march to a different beat to traditional conceptions of scientific knowledge that were predicated upon knowing a world that was not a moving target.

As pace-setters in the field, resilience ecologists are beginning to engage with such questions. Grimm and Redman muse that 'conscious inclusion of social and ecological variables in our studies, have brought many of us to ask a more fundamental question about our science' (2004b, 212). Continuing, they ask 'to what extent and in what ways do patterns and processes in human-dominated systems require qualitative changes to ecological

theory as it has been traditionally portrayed?' (2004b, 212). The work of SES ecologists more widely has also begun to suggest that resilience may require a science that is by necessity localised and qualitative. On the other hand, the ecologisation of the city within the SES framework is, at times, as reductionistic as anything previously attempted; for example, the study of urban fringe dynamics in Phoenix uses the language of 'pioneer' communities and 'stages of development' (Grimm and Redman 2004b, 212) familiar to the Chicago School before it.

Ethical approval forms and public participation are clearly insufficient to address either the political deficit of urban adaptation or the epistemological challenges of real-world experimentation from which they issue, but, currently, it is not clear exactly what is. The central role afforded to experimentation in current manifestations of urban sustainability undoubtedly offers up a potential space for more playful or insurgent political engagements with urban infrastructure and material form. If sustainability comes down to letting 1000 experimental flowers bloom, then it matters who gets to experiment, and how. As the crusading sanitarians of our day, ethnographies of urban ecologists in action (and scientists working in the field of adaptation) would contribute massively to our understanding of how adaptive governance is being transformed by scientist-practitioner-activist networks that render traditional distinctions obsolete (Chilvers and Evans 2009). It is surely this zeal to enact scientific knowledge and gain legitimacy that Dear tries to capture when he exhorts scholars to produce 'social histories of conviction rather than just accredited truth' (1995, 454).⁹ Geographers are well-placed to flesh out such political ecologies of adaptation.

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always, any erroneous statements are the responsibility of the author alone.

Notes

- 1 This paper focuses on adaptation as it derives from resilience ecology (Folke *et al.* 2002), indicating how systems can occupy a number of given states that are non identical. The classic example given is that of lakes, which can exist in a clear water state or be turbid with algal blooms. The first state provides more ecosystem services, but each is resilient to external shocks (Carpenter 2001). Ecological resilience focuses on systemic change, whereas social resilience tends to be more parochially concerned with recovery from disaster to an identical pre-existing state (Adger 2000). Resilience is also used in a narrow sense in relation to peak oil scenarios (for example, Newman *et al.* 2009; or David Holmgren's work on Future Scenarios [Holmgren 2009]), which do not necessarily advocate adaptive experiments.
- 2 While the Modernist dream of total control was also highly experimental, it was not concerned with hard-wiring adaptive learning into governance to produce environmental planning based around live feedbacks.
- 3 At least in the West. Sanitary infrastructure was only imperfectly adopted across much of the colonial world (Nilsson 2006; Prakash 1999).
- 4 Ecological science largely confined itself to site-level studies until the 1970s (Sukopp 2005), although the so-called 'Bio-Ecological Tradition' from Central Europe offered a minor counter discourse to systematisation, arguing that the low degree of integration means cities are better described by individualistic concepts (Weiland and Matthias 2009).
- 5 The sanitary/sustainable city comparison is not to suggest that rationality played any less important role in the mid to late twentieth century, for example in subsequent emphases on engineering and then ICT, but rather to highlight that these two eras heralded transformative reconceptualisations of the city.
- 6 The exact origins of the urban call are not clear, emerging from a complex network of actors on the east coast of the USA that was simultaneously hooked into international discussions concerning the ecological importance of cities.
- 7 The emergence of resilience onto the international stage as an environmental policy discourse awaits future treatment.
- 8 Of course, there are also a number of pressing practical reasons why scientists might shy away from producing 'local' science, wrapped up with the academic pressures to be 'internationally excellent', 'world class' and so forth (Evans 2006).
- 9 Indeed, this ethos is finding recognition in funding programmes such as the European Union funded

Social Polis project, which calls for 'activist science' in urban ecology (Kallis 2008).

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